Why "Energy Price Brakes" Encourage Moral Hazard, Raise Energy Prices, and Reinforce Energy Savings[*]

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Abstract

To help households and firms with exploding energy costs in the aftermath of the Ukraine war, a new policy called the "energy price brake" was implemented. A unique feature of this relief measure is that it provides a transfer that increases in the consumer's contractual per-unit price of energy. In a formal model, we show that this policy creates incentives for moral hazard of energy providers to raise per-unit prices. While this moral hazard problem increases the policy's fiscal costs, it also reinforces energy savings. Whether the policy's main beneficiaries are consumers or firms depends on the market structure.

JEL-Classification: D04, L12, Q48, K33.

Keywords: Energy Price Policies; Energy Crisis; Energy Saving; Energy Price Brake.

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1 Introduction

In the aftermath of the Russian invasion of Ukraine in February 2022, European governments have implemented various energy price relief programs for households and firms to address the skyrocketing energy costs. These programs, including lump-sum transfers, energy price subsidies, energy tax cuts, and price caps, aim to alleviate the financial burden for consumers caused by the crisis. But also avoiding a shortage of energy—especially, natural gas—has become a top priority for policymakers, particularly in Germany, where natural gas is the major energy source for both large firms and households.[1] While conventional measures like price caps or energy subsidies provide immediate relief to consumers, such approaches risk causing a breakdown in the energy market by creating excess demand.

To address these challenges, a novel policy instrument called the "energy price brake" was developed and implemented in Germany starting from January 1st, 2023, with a substantial budget of up to 200 billion euros being allocated to it. The energy price brake applies to both natural gas and electricity in Germany, and could also become a policy instrument in the EU in future energy crises (see EU 2023). Thus, an in-depth analysis of the effects of the energy price brake is warranted.

The energy price brake serves two primary objectives: (i) incentivizing energy savings among consumers and (ii) providing financial relief and protection against excessive energy prices. It operates through a transfer scheme defined by the following equation:

$$\text{“transfer} = (\text{contractual per-unit price} - \text{guaranteed per-unit price}) \times \text{quota.”} \tag{1}$$

Here, the "contractual per-unit price" refers to the consumer's current contractual price per unit of energy (that is, per kWh) that the energy provider determines, the "guaranteed per-unit price" refers to an energy price per kWh that the government sets upon implementing the energy price brake, and the "quota" refers to a fixed energy quantity that the consumer cannot influence after the announcement of the energy price brake (it could, for instance, refer to a percentage of the respective consumer's previous consumption level or a percentage of the median consumer's previous consumption level).[2] The transfer scheme behind the energy price brake is distinguishably different from other transfer schemes as it involves a lump-sum transfer that varies in the consumer's current contractual per-unit price.

In this paper, we provide a formal analysis of the effects of the energy price brake on energy

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[1] Germany was particularly hit by the shortage of gas. In Germany, natural gas was the major energy source both for large firms (with a share of 31.2% in 2020) as well as for households (with a share of 41.2% in 2019). But at the same time, 95% of natural gas in Germany had been imported, and Russian gas accounted for more than half of Germany's natural gas imports (see `https://www.destatis.de/DE/Presse/Pressemitteilungen/2022/07/PD22_N044_43.html` and `https://ec.europa.eu/eurostat/databrowser/view/NRG_TI_GAS__custom_2508592/default/table?lang=de`).

[2] In Germany, the implemented energy price brakes encompass a gas price brake and an electricity price brake. For households and small- and medium-sized firms, the "guaranteed price" is set to 12 euro cents per kWh for gas, and to 40 euro cents per kWh for electricity. The "quota" refers to 80% of the consumer's gas (electricity, respectively) consumption level in the billing period before the announcement of the energy price brake. For example, a household with 15,000 kWh gas consumption in the previous billing period and a contractual gas price of 22 euro cents would receive a transfer of 1,200 euros in the year where the gas price brake applies. Similar gas and electricity price brakes (with different quotas and different guaranteed prices) have also been implemented for large firms.

suppliers and consumers, which could be households or energy-consuming firms. For that, we build on a model of supplier-consumer contracting. First, suppose a monopolistic energy supplier ("he") that offers a two-part tariff contract contingent on the presence of the energy price brake, while the consumer ("she") decides whether to accept the contract and determines her energy consumption level.[3] We demonstrate that the energy price brake creates a moral hazard problem on the supplier's side, driven by the fact that the joint surplus of the supplier and the consumer increases with the contractual per-unit price. Because the supplier can extract the whole surplus via the fixed fee (keeping the consumer indifferent between accepting and rejecting the contract offer), he has an incentive to raise the per-unit price and therefore also the transfer opportunistically. By increasing the per-unit price, the energy price brake not only sustains but also strengthens the incentives for energy conservation. This, however, goes along with two drawbacks: First, given a monopoly supplier, the energy price brake fails to financially relieve consumers as the supplier pockets the entire additional surplus. Second, as the governmental transfer depends on the contractual prices, the fiscal costs of the energy price brake will be much higher than expected if policymakers do not take the moral hazard problem into account.

We next show that competition does not resolve the moral hazard problem. The intuition is that a consumer will choose the contract that gives her the highest utility. The consumer benefits from a higher per-unit price as this also raises her transfer. Thus, unlike under a monopoly, consumers are the beneficiaries of the transfer scheme. Also under competition, the transfer scheme is exploited, but here it helps to achieve both policy objectives (i.e., incentivizing energy savings and providing consumer relief).[4]

After this general analysis of the implications of an anergy price brake, we next look into the effects of the regulatory constraints instituted in Germany's recent legislation of the energy price brakes (EWPBG 2022, StromPBG 2022). Therefore, we add these regulatory constraints—which aim to ban the misuse of the transfer scheme—successively to our model. The first constraint regards the energy contract's per-unit price, the second the contract's fixed payment, and the third the overall transfer of the energy price brake to the consumer. Interestingly, we find that these regulatory constraints do not fundamentally alter our core insights.

First, the contractual per-unit price that a supplier can charge is constrained (but could well be above marginal costs). The legislation on the energy price brakes states that energy providers must not increase the price beyond *"an objectively justified"* amount (see §27 in EWPBG 2022 and

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[3] A two-part tariff mirrors the fact that energy contracts often specify an energy price per unit p and a "fixed payment" F per period. When signing a contract yields a lump-sum bonus payment (which is particularly widespread in energy markets, see Dertwinkel-Kalt et al. 2019 and Feldhaus et al. 2022), the fixed transfer between the contracting parties can also be negative.

[4] Both the monopoly case and the competition case could be valid for subsets of households. Competition authorities in the European Union regard energy markets as being split into two separate markets, one of which consists of loyal consumers who stay with their default provider, and the other one consists of switching consumers who search for the best offers, for instance, via price comparison websites (see, for instance, Haucap et al. 2012, p. 282). Also recent empirical studies suggest that a substantial share of consumers do not even consider switching the provider as a viable alternative so that their default provider de facto serves as a monopolist for this group (e.g., Handel 2013, Hortaçsu et al. 2017). The monopoly case also fits well for tenants whose house owner decides on the energy contract without internalizing the positive effects of switching providers for their tenants. For those that search for the best deal on price comparison websites, on the contrary, the competition case is applicable.

§39 in StromPBG 2022); otherwise, the Federal Cartel Office could intervene. As it is questionable whether the Federal Cartel Office has sufficient capacity to monitor price increases of all energy providers in the market,[5] firms' discretion to raise prices beyond what is *objectively justified* is arguably substantial, though not unlimited. We show that with this constraint in place the main message of our preceding analysis stays valid: the per-unit price is raised above the equilibrium level that would prevail in the absence of the transfer scheme.

Second, energy price brake regulations require that the fixed payment must reflect costs, and that bonus payments to consumers for signing a contract are virtually eliminated (see §4 (1) of EWPBG 2022). Given those restrictions, the supplier can effectively only set the contractual per-unit price. Then, the moral hazard problem will again arise under a monopoly and under competition, provided that *consumer utility* increases in the contractual per-unit price. Intuitively, a consumer benefits from a higher per-unit price when it increases the transfer by more than the energy bill. With linear contracts, there is no fixed fee via which surplus can be shifted between the consumer and the supplier, and thus a consumer does not unequivocally prefer high contractual prices. Whether a consumer wants to sign a high-price contract now depends on her demand curve. If the consumer's optimal consumption level lies above the quota, the consumer prefers a low-price contract. If it lies below the quota, however, she is willing to sign a high-price contract and the moral hazard problem arises.

Third, the transfer of the energy price brake itself is capped in such a way that a consumer cannot pay less than zero for her annual energy consumption. Without this constraint, the energy price brake would allow some extreme savers to lower their annual energy bill not only to zero but also below zero. This transfer cap could increase consumption up to a level that the bill becomes zero. Thus, it could increase an "extreme saver's" energy consumption, which is, as we show, the more likely the higher the contractual per-unit price. Nevertheless, the mass of such extreme savers is arguably negligible.

In addition, we consider also a scenario that is conceivable, but that is not part of the German legislation on the energy price brakes, namely, that the government implements a cost-based price regulation that strictly constrains the contractual prices suppliers can charge. Such a regulation of prices also does not solve the moral hazard problem. A consumer could have the incentive to sign a high-price contract as this ensures a higher transfer. Consumers with lower equilibrium energy consumption are more inclined to favor a high-price contract. With regulated prices, energy suppliers could respond to the demand for high-price contracts with the choice of higher-cost wholesalers.

Finally, we discuss other possible solutions to the moral hazard problem arising from the energy price brake. Here we also offer a remedy which entails imposing a limit on the extent to which the transfer can increase in response to a higher contractual per-unit price. Once this maximum level is reached, any further increase in the contractual price does not result in a higher transfer. This regulation allows the policymaker to constrain the milking incentives without

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[5] In Germany, for instance, there are about 900 German gas providers. This is due to the liberalization of the German energy markets that was implemented since 1998 in order to comply with EU directives. Municipal energy suppliers, which until 1998 had a defined supply area, were privatized and became today's 700 German basic gas suppliers; the remaining gas providers are entrant firms that do not operate as basic gas providers (more information can be found at `https://www.bundeskartellamt.de/EN/Economicsectors/Energy/energy_node.html`).

spoiling saving incentives or suppliers' profitability.

Our paper is organized as follows. In Section 2, we provide a graphical illustration of the incentives arising from the energy price brake (in comparison to alternative policies). In Section 3, we first present the basic set-up and and the benchmark analysis, where no relief program is in place (Section 3.1). Here, we derive the market outcomes under a monopoly and under competition when suppliers offer two-part tariff contracts. In Section 3.2, we introduce the energy price brake and show how it could be exploited with no constraints on the energy prices being in place, which highlights the incentives for moral hazard. In Section 3.3, we analyze the (arguably more realistic) case where the contractual per-unit price is restricted by legal constraints. In Section 4, we provide extensions on linear tariffs (Section 4.1), capped transfers (4.2), regulated prices (4.3), and potential solutions to the moral hazard problem (4.4), before we conclude in Section 5. All proofs are relegated to the Appendix.

Related literature. We contribute to the literature dealing with the energy crisis and the resulting energy policies (Bachmann et al. 2022, Kesternich et al. 2022, and Kruse-Andersen 2023) and, more generally, to the literature that evaluates energy savings policies (e.g., Reiss and White 2008, and Fraser 2022).

To the best of our knowledge, we are the first to investigate the energy price brake theoretically. We are also unaware of any work investigating a transfer scheme similar to the proposed price brake. Price caps and lump-sum transfers analyzed in the literature do not share the novel and distinguishing feature of the price brake that the joint surplus of firms and consumers increases in the price (given the price is not below marginal cost). While an alternative approach would be to start with the principal's optimization problem and derive optimal transfer schemes (see Laffont and Tirole 1993, Viscusi et al. 2018), our goal is to assess the effectiveness of the existing energy price brake and compare it to alternative instruments.

We contribute to the current policy debate on policies in the energy crisis (see Amaglobeli et al. 2023; Fabra 2023; Haan and Schinkel 2023; Sirin et al. 2023). Noteworthy in our context is the (informal) policy brief on the energy price brake (Atayev and Hillenbrand 2022) that points to the fact that this measure reduces consumers' incentives to search for better deals, which mitigates price competition and might raise prices.

2 A graphical illustration of the price brake vs. other energy policies

The energy price brake and its relation to other financial relief programs can be illustrated at the hand of the household's budget line. Suppose the household can spend her income m on energy consumption x (measured in kWh) and on other goods C (measured in euros).[6] Let p be the contractual energy price measured in euros per kWh, and suppose it exceeds the guaranteed price of the energy price brake. In this section, we abstract from the fixed payment, as we here focus on the opportunity costs of energy consumption, which are independent of the fixed payment included in a two-part tariff. Under the energy price brake, the household faces

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[6] Here we take the perspective of a utility maximizing household with monotone preferences. Similar arguments apply to an energy-consuming firm, which maximizes profits.

the budget line

$$px + C = m + T(p), \tag{2}$$

where $T(p) > 0$ is the transfer specified in Equation (1).

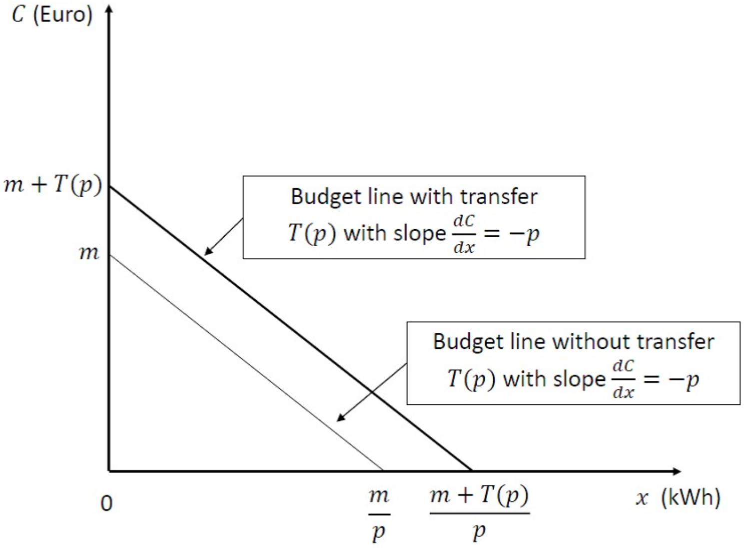

Figure 1: *The thin line gives the household's budget line without the energy price brake, and the thick line gives the budget line with the energy price brake.*

Figure 1 depicts the budget line of a household with and without an energy price brake in place. The horizontal axis represents the energy consumption level x, and the vertical axis the consumption expenditures on other goods C. In the absence of the energy price brake, the budget line is given by the thin line connecting the points $(0, m)$ and $(m/p, 0)$ with a slope of $dC/dx = -p$, which reflects the opportunity cost of energy consumption in terms of foregone expenditures on other consumption goods C. With the introduction of the energy price brake, the household receives a transfer $T(p)$, which is independent of its energy consumption in the current period. For a given price p, the transfer is, therefore, just like a fixed transfer payment to the household and does not affect the opportunity costs of energy consumption. Thus, the slope of the budget line is again given by $-p$, exactly as in the absence of such a transfer scheme (see the thick line in Figure 1). Moreover, the other elements of the energy price brake—namely, the guaranteed price and the quota—only affect the amount of the transfer and therefore do also not affect the opportunity costs of energy consumption.

Figure 2 elucidates the implications of the fact that the transfer of an energy price brake depends on the contractual energy price p. It shows how the household's budget line is affected when the contractual per-unit price increases from p (solid line) to p' (dashed line). Both budget lines intersect at the quota because then the household effectively pays the guaranteed price (as specified by the energy price brake) for the consumed quota. For all consumption levels below the quota, the budget line for p' lies above the one for p. This reveals the incentive for households with an equilibrium consumption level below the quota to choose energy contracts

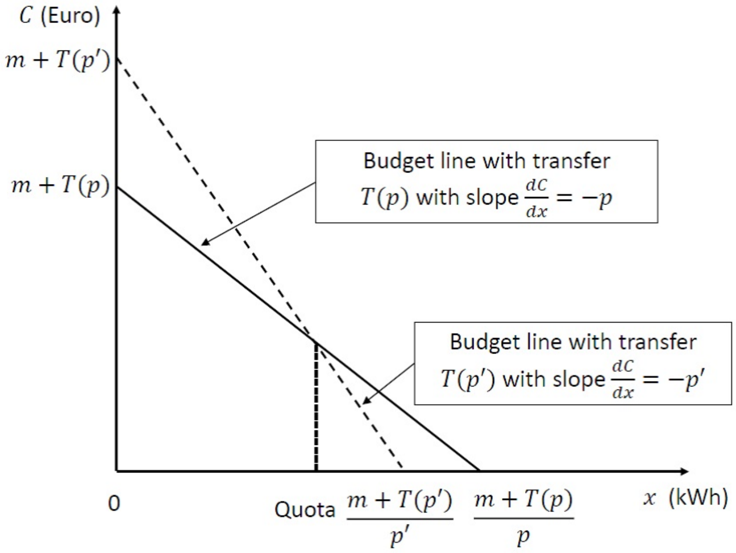

Figure 2: *Budget lines with energy price brake transfers for* p *(solid line) and* $p' > p$ *(dashed line).*

with high contractual prices.[7] If consuming less than the quota, the household effectively pays the guaranteed price for energy consumption but also benefits from the higher transfer for a higher contractual price; this relaxes her constraint on consuming other goods.

In the following, we compare the energy price brake to various other policies and measures implemented in the energy crisis. One obvious measure is a general cut on energy taxes, which was observed in several countries during the 2022/23 energy crisis (Sgaravatti et al. 2023). Such a tax cut reduces the relative costs of energy and turns the thin budget line in Figure 1 outward around the vertical intercept.

Furthermore, it is instructive to compare the energy price brake with a price-cap regulation such as the *Dutch energy price ceiling system* (for details see Haan and Schinkel 2023), where an energy price cap (of, for instance, 40 euro cents per kWh for electricity in 2023 in the Netherlands) applies to a certain quota.[8] Only for energy consumption that exceeds this quota, the contractual per-unit price applies.[9]

Figure 3 shows how such a price-cap regulation affects the household's budget line. The thin solid line represents the budget line without any intervention. The (kinked) dashed line depicts the budget line under a price cap regulation with a quota. For consumption levels below the quota, the opportunity costs of energy consumption are given by the capped price p^{CAP},

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[7] Whether a household is likely to set its consumption level above or below the quota crucially depends on how the quota is defined: If the quota is not-household-specific, but refers to a median or average nationwide energy consumption level (such a quota has been used, for instance, in the energy policies implemented in the 2022/23 energy crisis in the Netherlands and Austria), many households are particularly likely to consume less than the quota. This is because with a quota derived from average-sized household consumption levels, small households consume less than the quota, even without savings effort.

[8] Textbook-like price caps have also been implemented, for instance, in France and the United Kingdom. In the latter case, the energy regulator Ofgem calculates price caps for retail energy prices based on wholesale prices and other supplier operating costs (Sgaravatti et al. 2023).

[9] According to this regulation, energy providers are compensated by the government for the difference between contractual per-unit prices and the price cap; this could also give incentives for moral hazard by energy providers but, unlike the energy price brake, lowers energy savings incentives.

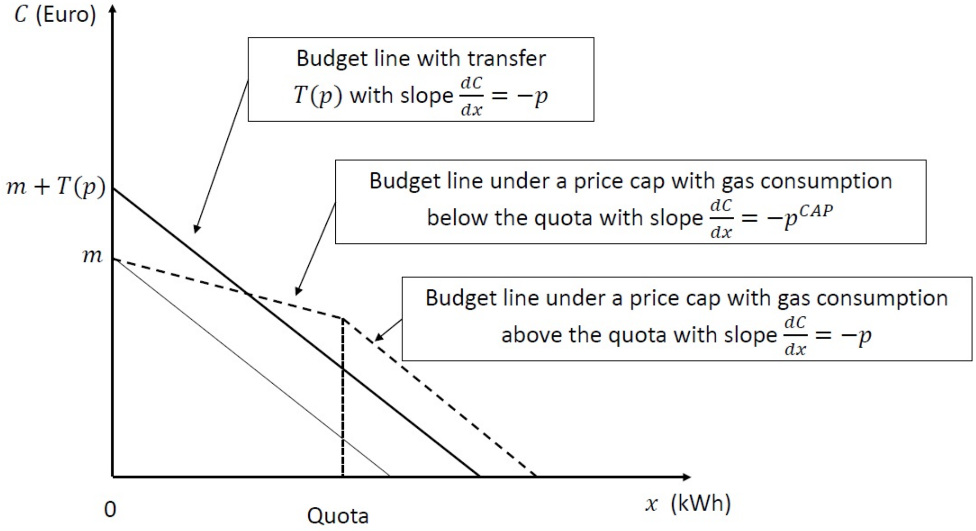

Figure 3: *Budget line without any intervention (thin solid line), with a price cap (dashed line), and with a price brake (thick solid line).*

which is smaller than the contractual price p. Only for consumption levels above the quota (as specified in the price cap regulation), opportunity costs are given by p. The thick solid line, on the contrary, represents the budget line under the energy price brake, where the opportunity costs of energy consumption are always given by p. Thus, *ceteris paribus*, the energy price brake should induce higher energy-saving incentives than under a price cap regulation.

Relatedly, Austria has implemented an energy price subsidy, where the government subsidizes the electricty price by paying a certain percentage of the energy price up to some consumption quota, but maximally 30 Cent per kWh.[10] For a given contractual price, the Austrian relief program gives rise to a budget constraint that resembles the one under the Dutch energy price ceiling system, as prices per unit are dampened up to some quota.

Energy vouchers reduce saving incentives by even more than the preceding policies. Countries like Croatia, France, and Portugal have implemented energy vouchers for some demanding groups (Sgaravatti et al. 2023), so that up to some certain quantity energy is free. This policy can be represented by the dashed budget line in Figure 3 when this is flat up to the kink.

Altogether, the discussed alternatives to the price brake (namely, price caps, energy price subsidies, energy vouchers, and tax cuts) reduce the opportunity costs of energy consumption (at least up to some quota) and could therefore aggravate the energy crisis in form of a possible market breakdown. The energy price brake (like a fixed transfer scheme) does not suffer from this problem, so that this scheme is particularly attractive when the risk of a market breakdown could pose a real problem. In fact, our analysis below shows that the energy price brake even tends to raise energy prices, so that energy saving incentives are reinforced by this policy.

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[10] The actual relief program that Austria implemented is much more complex, see Sgaravatti et al. (2023), but has at its core the elements on which we concentrate here. As the Dutch energy price ceiling system, this policy lowers the marginal energy price per unit and, therefore, the energy savings incentives, but yields also lower incentives for moral hazard than the price brake and the Dutch energy price ceiling system.

3 Model and analysis

3.1 Benchmark (without transfer scheme)

Suppose a monopolist supplier offers a two-part tariff contract with a contractual per-unit price $p \geq 0$ and a fixed payment F. The consumer's overall utility is

$$CS = \begin{cases} U(x) - px - F & \text{if the contract is accepted} \\ R & \text{if the contract is rejected,} \end{cases} \tag{3}$$

where $U(x)$ is the utility of consuming energy quantity $x \geq 0$, and $R \geq 0$ represents the consumer's reservation utility (i.e, the maximal utility the consumer can obtain when switching to the best alternative).[11]

Let $U(x)$ be at least twice continuously differentiable over $\mathbb{R}_{\geq 0}$. We impose further standard assumptions; namely, $U(0) = 0$, $U' := \partial U(x)/\partial x > 0$, and $U'' := \partial^2 U(x)/\partial x^2 < 0$. Thus, the utility from zero consumption is set to zero, utility is strictly increasing in the amount of energy consumed, and the marginal utility decreases with higher energy consumption levels.[12] Note that we do not impose restrictions on any other higher-order derivative of $U(x)$. In particular, the third derivative can be positive or negative and may also alternate its sign along $x > 0$.

The supplier's profit is given by

$$\pi := (p - c)x + F, \tag{4}$$

where $c \geq 0$ gives the marginal cost of energy supply. The *joint surplus* of the supplier and the consumer is then given by

$$CS + \pi = U(x) - cx. \tag{5}$$

Let $k := \lim_{x \to 0^+} U'$ be the choke price, that is, the lowest price at which demand is zero. To obtain a non-trivial solution in our following analysis, we impose the following assumption on the choke price and the joint surplus.

Assumption 1. *The choke price k satisfies $c < k < \infty$. In addition, there exists $x > 0$ so that there is scope for Pareto-improving trade, that is, $U(x) - cx > R$.*

The contracting game proceeds in two stages. In the first stage, the supplier ("he") offers a two-part tariff contract; in the second stage, the consumer ("she") accepts or rejects the offered contract. If she accepts, she determines her energy consumption level x. If she rejects, she realizes her reservation value R. We solve this game for subgame-perfect Nash equilibria.

If the consumer accepts the contract, she solves $\max_{x \geq 0} U(x) - px - F$. Her energy demand

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[11] This setup builds on a standard supplier-buyer trading model as, for instance, presented in Tirole (1988, p. 143).

[12] While this specification fits best to a household with a quasi-linear utility function, our specification also applies to an energy-consuming firm that uses energy as an input to produce a good that is sold in a perfectly competitive market at price q. For a standard production function $f(x)$ with $f' > 0$ and $f'' < 0$, the firm's profit function is parallel to (3), namely, $qf(x) - px - F$.

$x(p)$ then follows from the first-order condition

$$U' - p \leq 0, \tag{6}$$

which holds as an equality if the solution is strictly positive ($x(p) > 0$), in which case $dx(p)/dp = 1/U'' < 0$ holds (i.e., demand is downward sloping). If $U' < p$ for all $x > 0$, then $x(p) = 0$. The next lemma summarizes our results on the consumer's demand function.

Lemma 1 (Energy demand). *Suppose the consumer has accepted a two-part tariff contract with a contractual per-unit price* $p \geq 0$. *Then, her demand* $x(p)$ *follows from* (6) *and depends on* p *as follows:*

i) If $p \in [0, k)$, *then* $x(p) > 0$ *and* $dx(p)/dp = 1/U'' < 0$, *as well as* $\lim_{p \to k^-} x(p) = 0$.
ii) If $p \geq k$, *then* $x(p) = 0$.

The consumer accepts a contract offer if her participation constraint

$$U(x(p)) - px(p) - F \geq R \tag{7}$$

is satisfied, with $x(p)$ being characterized in Lemma 1. If $x(p) = 0$, then an acceptable contract must satisfy $F \leq 0$ with $|F| \geq R$; i.e., a fixed payment is made from the supplier to the consumer. If (7) is violated, the consumer rejects the contract offer and realizes R.

In the first stage of the game, the supplier anticipates the consumer's demand function $x(p)$ as well as her participation constraint (7), and sets a two-part tariff contract that solves

$$\max_{F,p} (p - c)x(p) + F \quad \text{s.t. } (7).$$

In equilibrium, the consumer's participation constraint must bind. Substituting this into the supplier's profit function, the supplier solves

$$\max_{p \geq 0} U(x(p)) - cx(p) - R, \tag{8}$$

which gives the first-order condition $U' - c = 0$. By Assumption 1, there exists a unique profit-maximizing two-part tariff contract (F^*, p^*) with $p^* = c$, so that $x^* := x(c) > 0$. This solution maximizes the joint surplus (5), because any price p larger or smaller than c decreases the joint surplus (for a proof see Lemma 2 in the Appendix). With the fixed payment F^*, the monopoly supplier extracts the entire joint surplus net of the consumer's reservation utility, so that $F^* = U(x^*) - p^*x^* - R > 0$ holds.

We proceed with the analysis of competition, where at least two suppliers with marginal costs c compete for the consumer. The contracting game under competition is as follows. In the first stage, suppliers simultaneously offer two-part tariff contracts to the consumer; in the second stage, the consumer accepts one of the contracts or rejects all offers. If the consumer accepts one of the contracts, she determines her energy consumption level x. If the consumer rejects all contracts, she realizes R. Again, we solve this game for subgame-perfect Nash equilibria.

If the consumer accepts one of the contracts, her demand is given by Lemma 1. When facing more than one acceptable contract, the consumer selects the contract with the highest overall utility; in case of indifference, the consumer selects each of the contracts with a strictly positive probability.

Under competition, all firms make zero profit, so that $F^{**} = 0$ and $p^{**} = c$ hold. In this case, the consumer pockets the entire joint surplus, which is maximal as in the monopoly case. Proposition 1 summarizes the benchmark results.

Proposition 1 (Benchmark result). *Assume that a supplier offers a two-part tariff contract. Then, the equilibrium both under monopoly and competition implements the joint surplus maximizing solution:*

i) *The contractual energy price per unit is equal to marginal costs:* $p^* = p^{**} = c$.

ii) *The consumer's energy consumption is* $x^* = x(c) > 0$.

Moreover, under a monopoly the fixed payment is $F^* = U(x^*) - cx^* - R > 0$ *and the consumer realizes overall utility of* $CS = R$*, while under competition the fixed payment is* $F^{**} = 0$ *and the consumer realizes* $CS = U(x^*) - cx^* > R$.

We can now analyze the most basic energy relief measure, namely, an unconditional fixed transfer to consumers, $T > 0$. This transfer is not part of the joint surplus of the supplier and the consumer net of her reservation utility, so that T does not affect the participation constraint (7), but only increases the consumer's overall utility by T. This holds obviously both under monopoly and under competition.

Corollary 1 (Unconditional fixed transfer). *An unconditional fixed transfer* $T > 0$ *from the government to the consumer only increases the consumer's overall utility by* T*, and does not affect the market outcome under monopoly or competition.*

3.2 Energy price brake: unconstrained contractual per-unit price

Suppose that prior to the contracting game, the government implements an energy price brake with a transfer $T(p)$ defined by

$$T(p) := \max\{(p - s)\alpha\overline{x}, 0\}, \tag{9}$$

where p is the contractual per-unit price that applies when the transfer scheme is in place, $s > 0$ is the guaranteed per-unit price, $\overline{x} > 0$ gives a reference energy consumption level, and $\alpha \in (0, 1)$ gives some share of the reference consumption level; we call $\alpha\overline{x}$ the "quota". Note that p is set by the supplier, while the government sets s and α.[13] The transfer $T(p)$ is therefore a lump-sum payment that increases linearly in the price set by the supplier, $\partial T(p)/\partial p = \alpha\overline{x} > 0$, as long as $p > s$. By this, the consumer's opportunity cost of any unit of gas consumption is left unchanged and given by the current contractual energy price p.

We assume that $s \in (0, c)$, so that the transfer is strictly positive for all $p \geq c$. Thus, given the benchmark equilibrium outcome (see Proposition 1), the transfer scheme, *ceteris paribus*, offers

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[13] For instance, Germany's gas price brake for households was specified by $s = 12$ euro cents per kWh, $\overline{x}$ equal to the household's gas consumption level in the previous year, and $\alpha = 80\%$.

financial relief for consumers in the form of a transfer payment $T(p^*)$, which is independent of the market structure (monopoly or competition).

With a transfer scheme $T(p)$ in place, overall consumer utility is given by

$$CS = \begin{cases} U(x) - px - F + T(p), & \text{if the contract is accepted} \\ R, & \text{if the contract is rejected.} \end{cases} \tag{10}$$

It follows that the introduction of $T(p)$ does not affect energy demand $x(p)$ (as given by Lemma 1) because the transfer does not depend on the energy consumption level x.

Critically, the transfer scheme affects the consumer's utility from accepting a certain contract, because the transfer *depends directly* on the contractual per-unit price. It follows that the consumer cannot realize the transfer without accepting the respective contract. Consequently, the introduction of the transfer scheme affects the consumer's participation constraint, which is now given by

$$U(x(p)) - px(p) - F + T(p) \geq R, \tag{11}$$

with demand $x(p)$ following from Lemma 1. Next, we analyze the first stage of the contracting game, both for the monopoly case and the competition case.

3.2.1 Monopoly

Anticipating the consumer's decisions in the second stage of the game, the supplier solves

$$\max_{F,p} \pi = F + (p - c)x(p) \;\text{ s.t. }\; (11).$$

In the optimal solution, the participation constraint (11) must bind. This can be achieved by setting $F = U(x(p)) - px(p) + T(p) - R$, which gives the reduced problem

$$\max_{p \geq 0} \widehat{\pi}(p) := U(x(p)) - cx(p) + T(p) - R. \tag{12}$$

The supplier's maximization problem (12) depends on the sum of the joint surplus, $U(x(p)) - cx(p)$, and the transfer, $T(p)$, which gives the "new" joint surplus of the supplier and the consumer under the energy price brake. Taking the derivative of $\widehat{\pi}(p)$ with respect to p gives

$$\frac{\partial \widehat{\pi}(p)}{\partial p} = \frac{U' - c}{U''} + \frac{\partial T(p)}{\partial p} \text{ for } x(p) > 0 \;\text{ and }\; \frac{\partial \widehat{\pi}(p)}{\partial p} = \frac{\partial T(p)}{\partial p} \text{ for } x(p) = 0. \tag{13}$$

Without a transfer $T(p)$, the optimal price would be the joint surplus maximizing price $p^* = c$ with $x^* > 0$ (see Proposition 1). Introducing the transfer scheme creates an incentive to raise the contractual per-unit price above c, because now $\partial \widehat{\pi}(p)/\partial p = \partial T(p)/\partial p > 0$ holds at $p = c$. Thus, the supplier raises the contractual per-unit price above the joint surplus maximizing price $p^* = c$ (see Proposition 1), so that energy consumption is reduced (according to Lemma 1) below the socially optimal level x^*.

Equation (13) uncovers the fundamental drawback of an energy price brake that is not protected by supplementary regulations against misuse. Inspecting the derivatives in (13) reveals the incentive to arbitrarily inflate the contractual per-unit price. For prices $p \in (c, k)$, the supplier's profit function could, in general, take many forms depending on the higher-order derivatives of $U(x)$ (see Lemma 3 in the Appendix). However, in this region, it is clearly bounded from above, because the joint surplus $U(x(p)) - cx(p)$ is strictly decreasing in p and becomes zero for $p \to k^-$ (see Lemma 2 in the Appendix), while $T(p)$ is linearly increasing in p. As the transfer payment of the energy price brake increases even for contractual prices above the choke price, the supplier's profit $\widehat{\pi}(p)$ is unbounded in p. Thus, by raising p above k, the supplier can realize a higher profit than for any price below k. The supplier can therefore realize an arbitrarily large profit by extracting the transfer from the energy price brake with the fixed payment, while allowing the consumer an overall utility of at least R.

Proposition 2 (Unconstrained contractual energy price under monopoly). *Suppose a transfer scheme $T(p)$ given by (9), and suppose that a monopoly supplier offers a two-part tariff contract to the consumer such that the consumer's participation constraint (11) holds. Then, the supplier can increase his profit by any amount by raising the contractual price per unit by sufficiently much. Thus, we have $p \to \infty$, $T(p) \to \infty$, and $\pi \to \infty$, while $x = 0$.*

3.2.2 Competition

Under competition, the consumer selects the contract which offers the highest overall utility. Since the energy price brake, as defined above, allows for milking the transfer scheme by any amount, it follows that $p \to \infty$ and $T(p) \to \infty$, so that $x = 0$ must hold. The main difference to the monopoly case is that competition forces firms to offer the most attractive contract to the consumer as, otherwise, she would not buy. Competition for the consumer's contract acceptance, therefore, inevitably induces firms to inflate the contractual energy price as this makes the contract offer most attractive. We summarize those results as follows.

Proposition 3 (Unconstrained contractual energy price under competition). *Suppose a transfer scheme $T(p)$ given by (9), and suppose that at least two suppliers offer two-part tariff contracts to the consumer, such that firms make non-negative profits. Then, $p \to \infty$, $T(p) \to \infty$, and $CS \to \infty$, while $x = 0$.*

Proposition 3 shows that competition leads essentially to the same outcome as a monopoly. Yet, in the monopoly case, it is the supplier who benefits from raising the contractual per-unit price above marginal costs because this increases his profit directly (given some consumer utility such that the consumer's participation constraint is satisfied); under competition, it is the consumer's decision rule to select the most attractive contract which induces firms to raise the contractual energy price (given some non-negative profit level if they sell).

3.3 Energy price brake: constrained contractual per-unit price

While our results on unconstrained milking of the energy price brake illustrate the incentives arising from this policy instrument, unconstrained milking represents an obvious misuse of the energy relief scheme.[14] Hence, assuming that the contractual price is constrained by some price $\overline{p}$, which ensures a strictly positive energy consumption level, is reasonable. Thus, in the following, we impose a maximum contractual energy price per unit, $\overline{p}$, with $\overline{p} \in (c, k)$, so that $x(\overline{p}) > 0$.[15] Note that this price constraint would never be binding in the benchmark case (see Section 3.1), where $p^* = p^{**} = c$ holds; that is, the purpose of $\overline{p}$ is to constrain potential misuse of the transfer scheme but not to lower regular energy prices.

3.3.1 Monopoly

The energy price constraint $p \leq \overline{p}$ effectively constrains the monopolist's ability to take advantage of the transfer scheme. Given $p \leq \overline{p}$, the following proposition specifies the equilibrium contract and its properties.

Proposition 4 (Constrained contractual per-unit price under monopoly). *Suppose a transfer scheme $T(p)$ given by (9), and suppose the additional constraint $p \leq \overline{p} \in (c, k)$ holds. Then, the monopoly supplier's equilibrium (two-part tariff) contract offer fulfills either i) or ii):*

i) *Interior solution: p fulfills $(U' - c)/U'' + \partial T(p)/\partial p = 0$, so that $p^* < p \leq \overline{p}$.*

ii) *Corner solution: p fulfills $p^* < p = \overline{p}$.*

Moreover, the supplier's profit is $\pi = U(x(p)) - cx(p) + T(p) - R$ and the consumer gets R, while $T(p) > T(p^*)$ and $0 < x(p) < x(p^*)$ always hold.

Proposition 4 shows that the introduction of the transfer scheme raises the per-unit price also when it is effectively constrained. It raises both the equilibrium price and the transfer beyond the levels that would prevail without the energy price brake. The optimal price either fulfills the condition of a local maximum, or it is obtained at $\overline{p}$. In any case, energy saving incentives are always reinforced by the introduction of the energy price brake (relative to the efficient energy consumption level x^*) but consumers are not relieved; they receive their reservation utility R and are indifferent to the situation without the transfer scheme.

3.3.2 Competition

Competition does not affect the contractual per-unit price and the energy consumption level as derived for the monopoly case. Note first that a consumer who faces more than one acceptable contract offer chooses the contract that yields the highest overall utility (10). Under competition, firms offer two-part tariff contracts that, again, maximize the joint surplus, but they make zero profits. Hence, the fixed payment must be negative with $F = -(p - c)x(p)$. Thus, on top of $U(x(p))$, the consumer also fully pockets the transfer $T(p)$ as well as the supplier's profit margin $(p - c)x(p)$, while her expenses are $px(p)$.

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[14] In Germany, this is forbidden in §27 (§39) of the German legislation on the gas (electricity) price brake (EWPBG 2022, StromPBG 2022).

[15] In practice, the exact value of $\overline{p}$ is not precisely specified but can be anticipated—to some extent at least—from cost-based or benchmarking methods the respective enforcement authorities typically use when they decide about abusive pricing (which happens regularly in, e.g., infrastructure industries).

Proposition 5 (Constrained contractual per-unit price under competition). *Suppose a transfer scheme* $T(p)$ *given by* (9), *and suppose the additional constraint* $p \leq \overline{p} \in (c, k)$ *holds. Then, under competition,* p *and* $x(p)$ *are the same as under a monopoly* (*i.e., they are as specified in Proposition* 4), *while suppliers realize* $\pi = 0$ *and consumers get* $CS = U(x(p)) - cx(p) + T(p) > R$.

Proposition 5 again shows that competition leads to the same market outcome as a monopoly. In both cases, the contractual per-unit price is increased above the socially efficient level (i.e., c). As in the monopoly case, the suppliers maximize the joint surplus (5) plus the transfer of the energy price brake $T(p)$. However, competition between suppliers drives profits to zero, which implies a negative fixed payment.

Propositions 4 and 5 show that introducing an energy price brake reduces energy consumption compared to the benchmark situation with no transfer scheme (or when compared with a fixed transfer payment; see Corollary 1). This result is a direct result of the facts that (i) the contractual energy price increases above c in the presence of the energy price brake, and (ii) energy demand is downward sloping (see Lemma 1). Thus, the energy price brake achieves the objective of reducing energy demand.

Moreover, Propositions 4 and 5 show that whether the objective of the energy price brake to to relieve consumers financially is reached depends on the market structure. This objective can be achieved with competition among suppliers because consumers then fully pocket the energy price brake transfers. On the contrary, consumers are not relieved in the presence of a monopolistic supplier that fully pockets the transfers from the energy price brake.

4 Extensions

In the following, we analyze how additional restrictions on energy supply contracts affect the equilibrium outcome under an energy price brake. First, we suppose that a supplier can only freely choose the contractual per-unit price (i.e., we have a regime of "linear energy contracts"); second, we examine the case of "capped transfers" (as specified in Germany's energy price brake legislation whereby a consumer's energy bill cannot be negative); and third, we consider (cost-based) "regulated energy prices". While those restrictions could limit the moral hazard problem induced by the energy price brake, they cannot eliminate it entirely. Finally, in a fourth extension, we discuss potential solutions to the moral hazard problem.

4.1 Linear energy contracts

If the supplier can set a two-part tariff contract, he can maximize the joint surplus with the per-unit price p, and share it efficiently with the fixed payment F. Energy market regulations, however, could constrain the providers' ability to set or alter the fixed payment.[16] How do our results change when the supplier can only set linear energy contracts, that is, the per-unit price? As in the previous section, we assume some maximal price $\overline{p}$ that the contractual per-unit price p cannot surpass; i.e., $p \leq \overline{p}$, with $\overline{p} \in (c, k)$.

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[16] The German legislation on the gas price brake states in §4 (1) of EWPBG (2022) that the fixed payment can only be changed if there is a cost-based justification. Otherwise, any "agreement about the fixed payment is void".

4.1.1 Monopoly

Assume a monopoly supplier and the same two-stage contracting game as before, with the only difference that the supplier can now only set a "linear" energy price p. Consumer utility is given by (3), with $F = 0$. If a consumer accepts the offer, her demand $x(p)$ is given by Lemma 1.

For a given transfer scheme $T(p)$ and energy demand $x(p)$, the participation constraint of the consumer is given by

$$CS(p) := U(x(p)) - px(p) + T(p) \geq R, \tag{14}$$

where the left-hand side of the inequality is the overall utility from accepting a contract with price $p < k$. Anticipating energy demand $x(p)$, the supplier solves

$$\max_{p} \ \pi(p) := (p - c)x(p) \ \text{ s.t. } \ (14). \tag{15}$$

Unlike the two-part tariff case, where the transfer scheme $T(p)$ can render an outcome with $x(p) = 0$ profitable (see Proposition 1), with linear prices, the profit is always zero when the per-unit price surpasses the choke price.

The profit function $\pi(p)$ has at least one local maximum.[17] To proceed parsimoniously, we impose the standard assumption that the marginal profit function changes its sign only once so that there is only one local maximum. In addition, we assume that $\overline{p}$ does not restrict the attainability of the unique local maximum (in fact, we can think of $\overline{p}$ being close to k). Hence, as before, the maximal price $\overline{p}$ is not used as some form of price-cap regulation to restrict the monopoly supplier's price-setting behavior in the absence of the energy price brake; however, it could restrict the exploitation of the transfer payment when an energy price brake is in place.[18]

Assumption 2. *The supplier's marginal profit $\partial\pi(p)/\partial p$ has at most one zero over (c, k), which we denote p^I. Moreover, $p^I < \overline{p}$.*

The analysis of the effects of the transfer scheme $T(p)$ depends on the contracting outcome in the absence of it. Given energy demand (Lemma 1), we have to distinguish two cases depending on whether or not the participation constraint

$$U(x(p)) - px(p) \geq R \tag{16}$$

is binding.

Case I (Participation constraint (16) not binding). The unique local maximum p^I gives the monopoly solution, and follows from the first-order condition

$$\frac{\partial\pi(p)}{\partial p} = x(p) + \frac{p - c}{U''} = 0. \tag{17}$$

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[17] Existence follows from the intermediate value theorem applied to $\partial\pi(p)/\partial p$ over $[c, k]$ due to $\lim_{p\to c^+} \partial\pi(p)/\partial p > 0$ and $\lim_{p\to k^-} \partial\pi(p)/\partial p < 0$.

[18] If, in contrast, $\overline{p}$ effectively restricts the price setting of the monopoly supplier, then introducing the energy price brake would be without consequences for the market outcome. Only the consumer would pocket the entire transfer of the energy price brake.

The supplier can implement the monopoly solution in the absence of a transfer scheme $T(p)$, if the associated consumer utility, $U(x(p)) - px(p)$, is higher than R (i.e., the participation constraint (16) does not bind at the monopoly price p^I). In this case, the transfer scheme is irrelevant to the contracting outcome, and the consumer will pocket the benefits of an introduction of a transfer $T(p^I)$. If the supplier can realize the monopoly solution p^I in the absence of the transfer scheme, its introduction does not change the market outcome because the monopolist cannot exploit it under a linear energy contract. This result, however, must change if the participation constraint binds, in which case the monopoly solution according to (17) is not feasible.

Case II (Participation constraint (16) binding). Alternatively, assume the participation constraint (16) is violated at the monopoly price p^I. Then, the monopolist sets the maximal price, denoted by p^{II}, such that the participation constraint (16) binds; that is, $U(x(p^{II})) - p^{II}x(p^{II}) = R$. The introduction of a transfer scheme $T(p) > 0$ then directly relaxes the consumer's participation constraint because $U(x(p^{II})) - p^{II}x(p^{II}) + T(p^{II}) > R$. Thus, with the introduction of the energy price brake, the price charged in the constrained solution p^{II} can be increased to some p with $CS(p) \geq R$ (see (14)).

How does overall consumer utility, $CS(p)$, that is, the left-hand side of inequality (14), depend on p? The effect of a marginal price increase on the consumer's overall utility is given by

$$\frac{\partial CS(p)}{\partial p} = -x(p) + \frac{\partial T(p)}{\partial p}, \tag{18}$$

where we used (6). Note also that

$$\frac{\partial^2 CS(p)}{\partial p^2} = -\frac{1}{U''} > 0, \tag{19}$$

so that $CS(p)$ is strictly convex in p for all $p < k$ (where $x(p) > 0$). Thus, we get

$$\frac{\partial CS(p)}{\partial p} \gtreqless 0 \Leftrightarrow \frac{\partial T(p)}{\partial p} \gtreqless x(p) \Leftrightarrow \alpha\overline{x} \gtreqless x(p). \tag{20}$$

Overall consumer utility can never increase in p without a transfer scheme. However, if there is a transfer scheme, $T(p)$, and a price $\widetilde{p} \in [0, \overline{p})$ for which $\partial CS(p)/\partial p = 0$ holds, then overall utility is increasing in p for all $p > \widetilde{p}$ until $\overline{p}$ is reached. For this to happen, the marginal utility loss from a price increase, $-x(p)$, must be smaller than the marginal increase of the transfer, $\partial T(p)/\partial p = \alpha\overline{x}$. This is more likely the larger p (because energy demand $x(p)$ is then relatively low) and the larger the quota $\alpha\overline{x}$. If the quota refers to an arguably relatively high pre-crisis consumption level, while $x(p)$ gives the lower demand at the high energy prices in the energy crisis, condition (20) for consumer utility increasing in price is likely to hold.

Referring to Germany's energy price brake legislation, which stipulates a quota of 80% of the consumer's energy consumption in 2021 (gas or electricity), condition (20) states that a consumer unambiguously benefits from a contractual energy price increase whenever her current energy consumption is below the quota. Note that this result is mirrored in the graphical illustration of the energy price brake for different contractual energy prices presented in Figure 2. There we showed that the consumer must be better off when choosing a contract with a higher contractual energy price whenever her energy consumption is smaller than the quota.

Thus, if consumers' overall utility is increasing in p according to (18) at the constrained solution, p^{II}, the supplier will raise the price to the unconstrained monopoly price p^{I}. In this case, current energy consumption under the constrained contractual energy price p^{II} is smaller than the quota; i.e., $\alpha\overline{x} > x(p^{II})$ holds.

We summarize these results as follows.

Proposition 6 (Linear price under monopoly). *Suppose a monopoly supplier that can only set the per-unit price* $p \in [0, \overline{p}]$*. The effects of* $T(p)$ *depend on whether or not the consumer's participation constraint (PC) is binding in the absence of* $T(p)$*:*

i) *PC not binding: The supplier sets the monopoly price* p^{I}*. The introduction of* $T(p)$ *has no effect on the market outcome and only increases consumer utility by* $T(p^{I})$*.*

ii) *PC binding: The supplier sets the constrained price* $p^{II} < p^{I}$ *in the absence of* $T(p)$*. The introduction of* $T(p)$ *has the following effects:*

    a) *It always relaxes the consumer's PC and therefore induces a price increase.*

    b) *If consumer utility increases in* p *in the presence of the transfer scheme, the monopoly solution* p^{I} *is realized. For this to happen, it is sufficient that* $\alpha\overline{x} > x(p^{II})$ *holds. Here, the introduction of* $T(p)$ *strictly increases the supplier's profit and the consumer's overall utility.*

    c) *Energy consumption is always reduced.*

Proposition 6 shows that the energy price brake can increase the energy price and reinforce energy savings, even with linear energy contracts. If consumer utility $CS(p)$ is increasing at the constrained monopoly solution p^{II}, this price increase benefits the supplier *and* the consumer. Thus, if the condition stated in Proposition 6, ii.b) applies, the energy price brake affects market outcomes in a similar fashion as in the "constrained" two-part tariff case (see Proposition 4). In the constrained two-part tariff case, the energy price brake creates an incentive to raise the price above the socially efficient price $p^{*} = c$ because the joint surplus of the supplier and the consumer is increasing in p; under a linear energy contract, the introduction of the energy price brake allows the supplier to raise the price above $p^{II} \geq p^{*} = c$ because now the consumer's utility $CS(p)$ is increasing in p.

4.1.2 Competition

Under competition, $p^{*} = c$ must hold in the absence of a transfer scheme $T(p)$ (see Proposition 1). If this equilibrium prevails with the introduction of $T(p)$, then consumers can pocket the entire transfer $T(p^{*}) > 0$. If, however, the transfer scheme implies that overall consumer utility is increasing in the contractual energy price at p^{*} (see (20)), then $\overline{p}$ is the unique equilibrium. If, alternatively, overall consumer utility increases not at p^{*}, but at a higher price in $(p^{*}, \overline{p}]$, then whether the equilibrium outcome is p^{*} or $\overline{p}$ depends on the exact shape of $U(x)$. Finally, if overall consumer utility is never increasing in p, then p^{*} is the unique equilibrium outcome. Consumer utility is always maximized, while firms could make strictly positive profits in the high-price outcome $\overline{p}$.

Proposition 7 (Linear price under competition). *Suppose competing suppliers can only set the per-unit price* p*. The introduction of* $T(p) > 0$ *has the following effects:*

i) *If consumer's overall utility increases at* $p^* = c$ *(which holds if* $\alpha\overline{x} > x(c)$ *according to (20)), then* $\overline{p}$ *is the unique equilibrium energy price. Here, both the suppliers and the consumer strictly benefit from the introduction of the energy price brake.*

ii) *If consumer's overall utility decreases at* $p^* = c$*, the equilibrium price is either* $p = c$ *or* $p = \overline{p}$*.*

Moreover, if $p = c$*, then energy consumption is* x^**. If* $p = \overline{p}$*, then demand is reduced to* $x(\overline{p}) < x^*$*.*

Proposition 7 shows that the energy price can increase under competition if energy consumption is smaller than the quota in the absence of the energy price brake. This result is mirrored in Figure 2, which shows that a consumer's budget set is increased through the transfer scheme if consumption is below the quota. If energy consumption is, without the price brake, above the quota, then the price brake can still increase the energy price if there is a price level $p \leq \overline{p}$ at which consumer utility increases. Clearly, then the introduction of the energy price brake and the resulting price increase must induce an energy consumption level below the quota.

Surprisingly, when the transfer scheme leads to a rise in energy prices, the equilibrium energy price may be higher in a competitive market compared to a monopoly setting. This is so because if the energy price increases under competition, then the energy price is always $\overline{p}$, while under a monopoly it could be smaller (for instance p^I).

We finally notice that the equilibrium outcome according to Proposition 7 coincides with the equilibrium outcome in the two-part tariff case when the fixed payment is constrained to be non-negative.

Corollary 2. *Assume competition and that suppliers can offer two-part tariff contracts with* $F \geq 0$*. Then the equilibrium outcome is the same as when firms can only set a linear energy contract (i.e., Proposition 7 applies).*

Corollary 2 follows directly from the observation that there cannot be an equilibrium where firms make zero profits and set a strictly positive fixed payment. Thus, Proposition 7 not only applies to the case of linear energy contracts but also to the case where suppliers offer two-part tariff contracts with non-negative fixed payments $F \geq 0$.

4.2 Capped Transfers

According to the German legislation on the energy price brakes (see, e.g., §3 (4) of the legislation on the German gas price brake), the transfer $T(p)$ cannot exceed the total annual energy bill. In other words, the consumer cannot pay less than zero for her energy contract.

Formally, given energy consumption x, the transfer $T(p)$ is capped if

$$px + F < T(p) \tag{21}$$

holds, where we allow for a two-part tariff contract. The capped transfer $\widetilde{T}(p)$ then fulfills $\widetilde{T}(p) = px + F$, and the consumer pays zero as long as (21) holds. If the fixed fee is not constrained by regulation, then the supplier will always increase it such that (21) binds. If this is not possible, because of a regulation of the fixed fee, the condition for a capped transfer (21) is still unlikely to hold as a consumer would have to reduce energy consumption drastically. In this case, our previous analysis is untouched.

However, there could be consumer types for which the condition (21) holds, because they find it particularly easy to save large amounts of energy. Ironically, if those consumers select a contract where (21) holds, then their expenses for energy are zero independently of the energy consumption level (as long as (21) holds). But then there is no incentive anymore to save energy up to a quantity denoted x_0 for which the transfer is just equal to the overall energy bill. The value of x_0 follows from

$$px_0 + F = T(p) = (p - s)\alpha\overline{x},$$

which gives

$$x_0 = \frac{(p - s)\alpha\overline{x} - F}{p}.$$

Note that

$$\frac{\partial x_0}{\partial p} = \frac{s\alpha\overline{x} + F}{p^2} > 0,$$

so that x_0 increases in p, while $\lim_{p\to\infty} x_0 = \alpha\overline{x}$. Given that the condition for a capped transfer (21) holds, a household's total energy expenses are zero for all $x \leq x_0$, where the critical value x_0 increases in the contractual per-unit price and approaches in the limit the quota of the energy price brake. Notably, this limit cannot be reached if the constraint $p \leq \overline{p}$ is in place (see Section 3.3).

Presumably, the relevance of the considerations in this subsection may be negligible, because only extraordinary savings in combination with the most expensive energy tariffs makes the transfer cap binding.[19]

4.3 Regulated Energy Prices

Let us now study the case where the government regulates the contractual per-unit price suppliers can charge. A standard approach is a cost-based price regulation, for instance, a regulation that fixes a supplier's price at $p^R := c + \varepsilon$, with $\varepsilon > 0$. Suppliers' marginal energy supply costs differ as they adopt different strategies to procure energy. As an example, suppose two types of suppliers with high and low marginal costs, c_H and c_L, respectively. Thus, with a cost-based price regulation in place, high-price suppliers charge $p_H^R = c_H + \varepsilon$, and low-price suppliers charge $p_L^R = c_L + \varepsilon$, with $p_L^R < p_H^R$. Assuming $p_H^R < k$, consumer demand is strictly positive for both prices; i.e., $x_H^* := x^*(p_H^R) > 0$ and $x_L^* := x^*(p_L^R) > 0$, while $x_L^* > x_H^*$ because $p_L^R < p_H^R$.

Without a transfer scheme $T(p)$, consumers would prefer the low-price contract, and high-price suppliers could only survive with locked-in consumers. However, with a transfer scheme

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[19] Take the example from Footnote 2 by the German Federal Ministry for Economic Affairs and Climate Action, and take a contractual gas price of 32 euro cents, which represented one of the highest gas prices charged in Germany in winter 2022/23. Then the German gas price brake offers a maximum transfer of $(0.32-0.12)0.8\cdot 15,000 = 2,400$ euro, which gives $x_0 = 2,400/0.32 = 7,500$ kWh. That is, the consumer pays nothing for gas as long as her consumption is not larger than 50% of her previous year's consumption.

$T(p)$ in place, high-price suppliers could survive in the market even if all consumers can easily switch suppliers.

Given the regulated prices, consumers choose the contract with the higher overall utility. In particular, consumers prefer the high-price contract over the low-price contract when

$$U(x_H^*) - p_H^R x_H^* + T(p_H^R) > U(x_L^*) - p_L^R x_L^* + T(p_L^R), \tag{22}$$

which holds if $x_L^* \leq \alpha \overline{x}$ according to (20). The interpretation is straightforward: Suppose a consumer selects the low-price contract and thus consumes x_L^*. Now, a marginal price increase reduces consumer utility by $-x_L^*$ but increases the transfer payment by $\alpha \overline{x}$. If the latter effect outweighs the former, the consumer must be better off by choosing the high-price contract.

Alternatively, we could also assume that suppliers can choose between two different marginal energy supply costs. Also then, some suppliers choose to have high costs to offer the high-price contract, which is demanded by those consumers who prefer to get the high-cost contract according to (22).

Overall, the transfer scheme can affect the market outcome even if the government imposes a cost-based price regulation. In this case, consumers could have incentives to sign the high-price contract as this ensures a higher transfer, and the drawback of a high-price contract is the lower, the lower one's equilibrium energy consumption.

4.4 Potential solutions to the moral hazard problem

How can the moral hazard problem induced by the energy price brake be reduced without spoiling consumers' saving incentives, consumers' relief, and firms' profitability? One potential approach to reducing the costs of the moral hazard problem is the implementation of an excess profit tax for energy providers. This tax has the potential to lower the costs by extracting excessive provider profits arising from moral hazard, which, however, only holds true in the absence of competition; with competition, consumers are the beneficiaries of the energy price brake. Another proposal to reduce the costs was put forth by Professor Isabell Weber, one of the creators of the policy, in her statement to the German Federal Parliament.[20] She suggested prohibiting consumers from switching to more expensive energy contracts. However, this proposal did not find its way into legislation, likely due to its high bureaucratic burden.

Conditioning transfers to consumers on (less manipulable) wholesale prices would also pose problems—it may not eliminate the moral hazard problem but rather shift it from the business-to-customer level to the business-to-business level, as wholesalers may opportunistically raise wholesale prices to exploit the energy price brakes. From a practical point of view, it could be cumbersome for policymakers to determine a supplier's wholesale price, as energy suppliers typically procure via different short- and long-term delivery contracts and also future contracts.

We will now discuss another potential solution that hinges on a modification of the transfer scheme. So far, the contractual per-unit price p was identical to the argument of the transfer

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[20] See `https://www.bundestag.de/resource/blob/925148/d15f316bd36c6b7ca44448d8e4e21d2f/Stellungnahme_SV_Prof-_Dr-_Dr-_Isabella_M-_Weber-data.pdf`.

$T(\cdot)$—which we here call the *transfer-relevant price*. One potential solution to the moral hazard problem lies in capping the latter (the transfer-relevant price) without capping the former (the contractual per-unit price): accordingly, for a contractual price p the transfer is defined by $T(\min\{p, \widehat{p}\})$ with some governmental-defined threshold value $\widehat{p} > s$ and $T(\cdot)$ being defined by (9). Here, $\min\{p, \widehat{p}\}$ gives the *capped transfer-relevant price*. Put differently, according to this policy the transfer is, given a contractual per-unit price p, equal to $\widehat{T}(p)$ being defined by

$$\widehat{T}(p) := T(\min\{p, \widehat{p}\}) = \begin{cases} \max\{(p-s)\alpha\overline{x}, 0\} & \text{if } p \in [0, \widehat{p}] \\ (\widehat{p}-s)\alpha\overline{x} & \text{if } p > \widehat{p}. \end{cases} \tag{23}$$

This constraint is different from the restriction of the contractual per-unit price as introduced in Section 3.3, as suppliers are not constrained in their price setting (the contractual price p can be higher than $\widehat{p}$), but increasing p above $\widehat{p}$ cannot increase the transfer above the maximal possible value, $\widehat{T}(\widehat{p}) = (\widehat{p}-s)\alpha\overline{x}$, anymore.[21]

In the following, we elaborate on the consequences of capping the transfer-relevant price via some $\widehat{p} \geq s$. How does this constraint affect the equilibrium outcomes under a two-part tariff and under a linear energy contract? Suppose that energy consumption $x(p)$ is strictly positive at $\widehat{p}$, that is, $\widehat{p} < k$. As before, suppose $s < c$, so that $\widehat{p}$ could be below or above c.

First, we consider the case $\widehat{p} \leq c$, that is, the energy price brake is capped at some contractual per-unit price below the marginal costs of energy supply. In this case, the transfer from the energy price brake (23) is a fixed transfer, given by $\widehat{T}(\widehat{p}) = (\widehat{p}-s)\alpha\overline{x}$. This is because the equilibrium contractual per-unit price p cannot be lower than c, independent of the supply structure and whether the energy contract is a two-part tariff or a linear contract. In the case of a two-part tariff, the market outcome is then given by Corollary 1. In the case of a linear energy contract with a monopoly supplier, the market outcome with transfer scheme (23) depends on the market outcome in the absence of it. If the consumer's participation constraint (16) is not binding at the unconstrained monopoly price p^I, then this price remains valid after the introduction of (23). If, however, the consumer's participation constraint (16) binds at p^I, its introduction relaxes the consumer's participation constraint (16), so that the monopolist will increase the contractual per-unit price. In this case, energy consumption is reduced. If there is competition and the energy contracts are linear, then the transfer scheme (23) does not alter the competitive price level $p^* = c$; implying that consumers fully pocket the transfer.

In sum, if $\widehat{p} < c$, then the transfer (23) only changes the energy market outcome if a monopoly supplier sets a linear energy contract and the monopolist's price setting is effectively constrained by the consumer's participation constraint. Only then the introduction of an energy price brake (23) unfolds a price increasing effect driven by the supplier's incentive to take advantage of the

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[21] Incidentally, the German parliament has recently passed a regulation that supplements the laws of the energy price brakes (DBAV 2023), which limits the applicability of the energy price brakes up to some maximal contractual per-unit price. It only applies to large energy-consuming firms which are entitled to receive transfer payments from the energy price brakes above 2 million euros. The regulation states that the maximal difference $p-s$ cannot be larger than 8 euro cents per kWh for gas and 24 euro cents per kWh for electricity. Noting that the laws on the energy price brakes specify guaranteed per-unit prices for large energy-consuming firms of 7 euro cents for gas and of 13 euro cents for electricity (both net of taxes), it follows that the maximal contractual per-unit price for which the energy price brakes apply is capped for gas at $\widehat{p} = 7 + 8 = 15$ euro cents per kWh and for electricity at $\widehat{p} = 13 + 24 = 37$ euro cents per kWh.

transfer payment.

Second, let us consider the case $\widehat{p} > c$. Assume first a two-part tariff contract. It is straightforward to see that Propositions 4 and 5 also apply here, with the only adjustment that we have to substitute $\overline{p}$ by $\widehat{p}$. This follows from the fact that for any $p > \widehat{p}$ the joint surplus, $\Pi(p)$ (see Lemma 3 of the Appendix), must decrease strictly; i.e., $\partial\Pi(p)/\partial p < 0$ for all $p \in (\widehat{p}, k)$. With a two-part tariff the joint surplus must be maximal, so that we can savely rule out any contractual per-unit price p above $\widehat{p}$.

Finally, consider the case of a linear energy contract, for which $\widehat{p} > c$ holds. Here a consumer's overall utility $CS(p)$ is strictly decreasing on $(\widehat{p}, k)$. Thus, under competition, the contractual per-unit price cannot be larger than $\widehat{p}$, and Proposition 7 holds when substituting $\overline{p}$ by $\widehat{p}$. Now consider the monopoly case. The introduction of the transfer scheme (23) can only affect the market outcome if the unconstrained monopoly price p^I violates the consumer's participation constraint in the absence of the price brake (16). The introduction of (23) then not only relaxes the consumer's participation constraint, but could also increase the contractual energy price p above $\widehat{p}$, because by this the monopolist comes closer to the unconstrained monopoly solution without violating the consumer's participation constraint.

Overall, we see that a cap of the transfer-relevant price via some $\widehat{p}$ into the price brake formula can be used to effectively constrain the moral hazard problem. As firms can always choose prices higher than $\widehat{p}$, suppliers' profitability is never an issue. Note, however, that with a capped transfer-relevant price, consumers are—unlike under the original energy price brake—not fully protected against rising prices.

5 Conclusion

We have formally delineated the incentives for moral hazard that arise from an energy price brake. As the joint surplus of consumers and providers increases in the contractual per-unit price, both parties could prefer contracts with particularly high prices. Increased competition among providers does not mitigate this effect but merely redistributes the rents from suppliers to consumers. Thus, whether the objective of relieving consumers is satisfied, depends on the degree of competition in the energy market. We also show that the energy price brake is particularly well suited to achieve the policy's objective of energy saving. While this policy ensures that the opportunity costs of energy consumption are aligned with market prices, it also has the tendency to drive up energy prices. Consequently, the policy not only preserves but also strengthens energy-saving incentives. Nonetheless, our analysis suggests that the price brakes could become more expensive than initially estimated.[22]

In the course of the implementation of the energy price brakes in Germany, the public discussion centered on how consumers can shield themselves from soaring energy prices. This focus neglects that consumers can actually benefit from price increases and therefore may actively *seek*

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[22] Based on the given guaranteed gas price of 12 euro cents per kWh and the total gas consumption by German households and small- to medium-sized firms in 2021 of $\overline{x} = 433.487$ TWh, a 10%, 20% or 30% price increase would result in an additional expenditure of about 4.16, 8.23 or 12.48 billion euros for German taxpayers. This back-of-the-envelope calculation provides an approximate estimation of the fiscal costs associated with exploiting the German gas price brake.

higher contractual prices. It is precisely this feature of the price brakes that can render outright price regulation ineffective. Even if providers are restricted to cost-based prices, consumers may still prefer high-price contracts because of the benefits of the transfer scheme.

There is suggestive evidence that the moral hazard problem identified in this paper is a genuine concern. Following the implementation of energy price brakes, the Federal Cartel Office in Germany established a dedicated department to investigate potential misuse of the policy. By June 2023, this department had already initiated investigations into a two-digit number of energy providers suspected of exploiting the energy price brakes (Bundeskartellamt 2023).

While energy price brakes apply to households and all energy-consuming firms, our analysis applies best to households and relatively small firms. Larger firms, instead, can directly negotiate the terms of energy contracts, which could yield more complex contracts than two-part tariffs. For instance, contractual prices per kWh and supplied quantities can be decoupled when the space of feasible contracts is sufficiently rich. This additional flexibility arising in negotiations can arguably be misused to milk the energy price brakes even beyond what is possible with two-part tariff contracts.

One potential solution to the moral hazard problem lies in imposing a limit on the extent to which the transfer can increase in response to a higher contractual per-unit price. While this does not fully protect consumers against rising prices, it dampens incentives for moral hazard and ensures energy suppliers' profitability while maintaining incentives for savings.

Whether the energy price brake indeed increases energy prices is ultimately an empirical question. Future research could address this question by employing a differences-in-differences approach and analyzing data on offered energy contracts from two countries with comparable energy markets, where one country implements the energy price brake, while the other does not.

Appendix

Proof of Lemma 1. *Part i).* By $U' > 0$ and $U'' < 0$ for all $x > 0$, as well as Assumption 1, U' has its supremum at $\lim_{x\to 0^+} U' = k$. Thus, there is a unique solution to (6) with $x > 0$ for all $p \in [0, k)$, which defines the demand function $x(p)$ for the considered interval. By the implicit function theorem, the energy demand function $x(p)$ is continuously differentiable for all $p \in [0, k)$ with slope $dx(p)/dp = 1/U'' < 0$. This proves part i) of the lemma.

Part ii). By definition of the choke price k, demand must be zero for $p = k$; demand must be zero also for any price $p > k$, because the left-hand side of (6) is then strictly negative. $\square$

Proof of Proposition 1. First, consider the monopoly case. The supplier solves (8). This problem is equivalent to the maximization of the joint surplus (5) of the supplier and the consumer. To proceed with the proof of this proposition, we need the following lemma that specifies the properties of the joint surplus when energy demand is $x(p)$ as specified in Lemma 1.

Lemma 2 (Joint surplus in the benchmark). *Given energy demand $x(p)$, the joint surplus of the supplier and the consumer, $U(x(p)) - cx(p)$, has a unique maximum at $p^* = c$.*

i) It is strictly increasing in p *for all* $p \in [0, c)$ *and it is strictly decreasing in* p *for all* $p \in (c, k)$, *with* $\lim_{p \to k^-} [U(x(p)) - cx(p)] = 0$.

ii) It is zero for all $p \geq k$.

Proof of Lemma 2. Assuming $x(p) > 0$ and using Lemma 1, we get

$$\frac{\partial}{\partial p} [U(x(p)) - cx(p)] = \frac{U' - c}{U''} \text{ for } 0 \leq p < k. \tag{24}$$

By (6), $\frac{U'-c}{U''} \underset{<}{\overset{\geq}{=}} 0 \Leftrightarrow p \underset{>}{\overset{\leq}{=}} c$. Note also that $\lim_{p \to k^-} [U(x(p)) - cx(p)] = 0$ follows from $\lim_{p \to k^-} x(p) = 0$ and $U(0) = 0$, while part ii) follows from $x(p) = 0$ for all $p \geq k$ (Lemma 1). Thus, the joint surplus has a unique maximum at $p^* = c$. ☐

Part i) of the proposition for the monopoly case follows immediately from Lemma 2 because the solution to (8) must be the same as the solution to the maximization of the joint surplus. Part ii) for the monopoly case follows from Assumption 1, so that the energy consumption level is strictly positive and the socially optimally one. In equilibrium, the consumer's participation constraint (7) must bind, so that the fixed fee is given by the maximal joint surplus net of the consumer's outside option utility; i.e., $F = U(x^*) - cx^* - R$, which is also the supplier's equilibrium profit. The consumer then obtains $CS = R$.

Under competition, suppliers are perfectly substitutable from the consumer's perspective (as there is no product differentiation; moreover, marginal costs are constant and the same for all suppliers), so that the consumer always chooses the contract offer with the highest overall utility CS. It is then straightforward to see that the equilibrium contract offer must maximize the consumer's overall utility (i.e., the contractual per-unit price is set to marginal costs to maximize the joint surplus according to Lemma 1), while no supplier can realize strictly positive profits with $F > 0$ (as the supplier could be undercut by $F - \varepsilon$, with $\varepsilon > 0$). It follows that $p^* = c$ and $F = 0$ must hold under competition, so that any supplier's profit is zero while the consumer's overall utility is equal to the maximal joint surplus; i.e., $CS = U(x^*) - cx^*$. ☐

Proof of Corollary 1. An unconditional fixed transfer $T > 0$ neither affects the consumer's participation constraint (7) nor the consumer's energy demand according to Lemma 1. It, therefore, does also not affect the supplier's maximization problem, so that the market equilibrium as described in Proposition 1 remains the same. ☐

Proof of Proposition 2. The supplier faces maximization problem (12). To understand its solution, it is helpful to examine how p affects the sum of the joint surplus (see Lemma 2) and the transfer $T(p)$; this then determines the marginal profit (see (13)). Given energy demand $x(p)$ according to Lemma 1, the following lemma specifies the properties of the joint surplus, $U(x(p)) - cx(p)$ (see Lemma 2), augmented by the energy price brake $T(p)$, which we define by

$$\Pi(p) := U(x(p)) - cx(p) + T(p). \tag{25}$$

Lemma 3 (Joint surplus with energy price brake). *Assume the government offers an unconstrained energy price brake (9) to the consumer. Then* $\Pi(p)$, *fulfills the following properties:*

i) *It is continuous everywhere and it is differentiable for all* $p \geq 0$ *except at* $p = s$ *and* $p = k$*, where it has two kinks.*

ii) *It is strictly increasing for all* $p \in [0, c]$*, obtains the value* $T(k)$ *at* $p = k$*, and it has the constant slope* $\partial\Pi(p)/\partial p = \partial T(p)/\partial p = \alpha\overline{x} > 0$ *for all* $p > k$*.*

iii) *It is bounded from above and from below on* $[c, k]$*.*

iv) *On* $[c, k]$*,* $\Pi(p)$ *has a maximum either at some* $p \in (c, k)$ (*interior solution*) *or at* $p = k$ (*corner solution*)*.*

Proof of Lemma 3. Note first that $\Pi(p)$ is the sum of $U(x(p)) - cx(p)$ (which properties are given in Lemma 2) and $T(p)$. Note that $T(p) = 0$ for $p \leq s$ and $T(p)$ linearly increasing with slope $0 < \partial T(p)/\partial p < \infty$ for all $p > s$.

Part i). By Lemma 2, $U(x(p)) - cx(p)$ is continuous in p and has a kink at $p = k$, while $T(p)$ is linear in p for $p > s$. Moreover, $T(p)$ is zero for $p \leq s$ and linearly increasing for all $p > s$, so that $T(p)$ is also continuous and has a kink at $p = s$. It follows that $\Pi(p)$ is continuous in p with two kinks at $p = s$ and $p = k$. Likewise, $\Pi(p)$ is differentiable everywhere except at points $p = s$ and $p = k$.

Part ii). By Lemma 2, $U(x(p)) - cx(p)$ is increasing in p for $0 \leq p \leq c$ (with a zero at $p = c$), while $T(p)$ is strictly increasing in p for all $p > s$, with $s < c$. Thus, $\Pi(p)$ is strictly increasing in p for all $0 \leq p \leq c$; and in particular, at $p = c$. By Lemma 2, $U(x(p)) - cx(p)$ is zero for $p \geq k$, while $T(p)$ is linear for all $p > s$.

Part iii). An upper bound is given by $\Pi(p) < \Pi(c) + \Pi(k) < \infty$, which follows from $U(x(p)) - cx(p)$ strictly decreasing in p (see part ii) of Lemma 2) and $T(p)$ linearily increasing in p. A lower bound is given by $\Pi(p) > 0$, which follows from $\lim_{p\to k^-} U(x(p)) - cx(p) = 0$ (Lemma 2) and $T(p) > 0$ for all $p \in [c, k]$.

Part iv). Because of part ii), there cannot be a maximum at $p \leq c$. Then, there are two possible cases: either $\partial\Pi(p)/\partial p > 0$ for all $c \leq p < k$, with $\lim_{p\to k^-} \Pi(p) = T(k)$, or there exists at least one price $p \in (c, k)$, where the condition for a local maximum $\partial\Pi(p)/\partial p = 0$ holds. In the former case, the unique maximum is reached at $p = k$, while in the latter case, there are two possible candidates for a maximum: either at a price $p \in (c, k)$, where $\partial\Pi(p)/\partial p = 0 = 0$ holds, or at $p = k$. The former solution gives the interior solution and the latter one the corner solution. ☐

Note that a solution to the supplier's maximization problem (12) must also maximize $\Pi(p)$ as they differ only in the constant R. Thus, Lemma 3 allows us to characterize also the marginal profit (see (13)) and therefore prove the proposition. First, $p^* = c$ cannot be a solution because at this point the firm's marginal profit strictly increases (by part ii) of Lemma 3). For $c < p \leq k$ there may exist an interior maximum (by parts iii) and iv) of Lemma 3) and/or a maximum at $p = k$ where the profit is given by $T(k)$. As the firm's profit can be raised by any amount due to $T(p)$ for $p > k$ with $x(p) = 0$, the first part of the proposition follows. It is then obvious that there is also a large enough contractual energy price with $T(p) > R$, which allows the supplier to extract the arbitrarily large transfer which gives the last part of the proposition. ☐

Proof of Proposition 3. Suppose a firm offers a contract (p, F) that is accepted by the consumer. Given the consumer's energy demand, the firm's profit is $\pi = (p - c)x(p) + F$, which gives $F =$

$\pi - (p-c)x(p)$. Substituting this into the consumer's overall utility (3), we get $CS(p,F) := \Pi(p) - \pi$. Thus, when the consumer faces different contracts that satisfy the participation constraint (11), the consumer selects the contract with the highest overall utility. Firms thus compete in two-part tariffs (p,F) to maximize the consumer's overall utility which must lead to $p \to \infty$, because then the transfer from the energy price brake also becomes arbitrarily large. Subtracting a fixed profit level does not compromise the attractiveness of the contract. □

Proof of Proposition 4. The supplier solves (12) under the additional constraint $p \leq \overline{p}$. The statements of the proposition then follow from Lemma 3. In particular, part iv) of Lemma 3 also applies to the subinterval $p \in [c, \overline{p}]$. Thus, $\Pi(p)$ either has maximum at some $p \in (c, \overline{p}]$, where the condition for a local maximum

$$\frac{\partial \pi}{\partial p} = \frac{\partial \Pi(p)}{\partial p} = \frac{U' - c}{U''} + \frac{\partial T}{\partial p} = 0$$

holds ("interior solution"), or it obtains a global maximum at $p = \overline{p}$ ("corner solution"). While $\Pi(p)$ is not differentiable at $p = k$, it is differentiable at $\overline{p}$, which implies that the condition for a local maximum could be satisfied at $p = \overline{p}$.

By Assumption 1, both the interior and the corner solution can be implemented by the supplier with a fixed payment, which leaves an overall utility of R to the consumer. The supplier then realizes the profit as stated in the proposition. Both the interior and the corner solution increase the contractual energy price above $p^* = c$, so that energy demand decreases with $x(p) < x(p^*)$. Clearly, the transfer of the energy price brake is also larger when compared with the transfer that would result from the price in the benchmark case where $p^* = c$. This proves the proposition. □

Proof of Proposition 5. To prove this proposition, we can use Proposition 3. Again, firms compete in offering two-part tariff contracts, while the consumer selects the contract that gives her the maximal overall utility $CS(p,F) = \Pi(p) - \pi$. It is then obvious that a firm cannot make a positive profit, and p is chosen to maximize $\Pi(p)$ (i.e., the sum of the joint surplus plus the transfer from the energy price brake). Only if at least two suppliers offer such a contract, there is no profitable unilateral deviation incentive; i.e., we have reached a subgame-perfect equilibrium. Thus, the equilibrium price is either obtained as an interior solution or a corner solution. It then must also hold that energy consumption is strictly lower than in the benchmark case without an energy price brake. Finally, and in contrast to the monopoly outcome as described in Proposition 5, firms now make zero profits while the consumer fully pockets the joint surplus including the transfer of the energy price brake. Notably, here the fixed payment is strictly negative (i.e., the consumer gets a bonus payment), so that $F = -(p-c)x(p)$ holds. □

Proof of Proposition 6. We first analyze the equilibrium without the energy price brake $T(p)$. Given (16) holds, the monopoly supplier sets the price p^I according to (17), where Assumption 2 guarantees that p^I is unique and feasible (i.e., $p^I < \overline{p}$). Thus, the standard monopoly solution, p^I, is the equilibrium outcome whenever (16) is not binding at this price. If, to the contrary, (16) is violated at p^I, then the monopolist sets the highest possible price p^{II} where (16) holds as an equality. This follows from noticing that the left-hand side of (16)—namely, consumer utility—is strictly decreasing in p, with

$$\frac{\partial}{\partial p}\left[U(x(p)) - px(p)\right] = -x(p) < 0, \tag{26}$$

where we used (6). Thus, there is a unique price $p^{II} < p^{I}$ where the consumer's particiption constraint (16) holds as an equality (existence follows from Assumption 1). By Assumption 2, the supplier's profit is strictly increasing in p for all $p < p^{I}$, so that it is indeed optimal for the supplier to set the price p^{I}, where (16) holds as an equality.

Next assume that an energy price brake $T(p) > 0$ is in place. The introduction of $T(p)$ has the effect that it relaxes the consumer's particiation constraint (16), which is now given by (14). Consequently, when p^{I} (according to (17)) is the solution to (15) for $T(p) = 0$ (i.e., with no energy price brake in place), then this must also be the solution when $T(p) > 0$ holds. Thus, the introduction of the energy price brake has no effect on the contractual energy price p^{I}, energy demand $x(p^{I}) > 0$, the monopolist's profit $\pi(p^{I})$, and it only increases the consumer's utility by $T(p^{I})$ from $U(x(p^{I})) - p^{I}x(p^{I})$ to $U(x(p^{I})) - p^{I}x(p^{I}) + T(p^{I})$. This proves part i) of the proposition.

Now suppose that (16) is binding in the profit maximizing solution to (15) for $T(p) = 0$, so that the monopolist sets $p^{II} < p^{I}$, where (16) holds as an equality. Again, the only effect of the introduction of the energy price brake, with $T(p) > 0$, is to relax the consumer's particiation constraint (16), which is now given by (14). Clearly, the consumer's participation constraint (14) must be slack at p^{II}. As the supplier's profit is strictly increasing in p at $p^{II} < p^{I}$ (Assumption 2), he will always increase the price above p^{II}. This proves part ii.a) of the proposition.

As shown in the main text, the left-hand side of (14) (i.e., $CS(p)$) either increases or decreases at any $p \leq \overline{p}$ (according to (20)), and it is strictly convex (see (19)). Thus, if $\partial CS(p)/\partial p > 0$ at p^{II} (which holds if $\alpha\overline{x} > x(p^{II})$ according to (20)), then the supplier can profitably increase the price above p^{II} up to p^{I} (the standard monopoly solution (17)), because any such price increase must further relax the consumer's participation constraint (14); that is, any increase in p also increases the consumer's overall utility $CS(p)$. Thus both the supplier and the consumer strictly benefit from the introduction of the energy price brake. This proves part ii.b) of the proposition.

The introduction of the energy price brake, therefore, always increases the contractual energy price, so that part ii.c) of the proposition follows directly from Lemma 1. □

Proof of Proposition 7. Under competition, the consumer selects the contract which gives the highest utility (3), given that the utility is not smaller than R. If there is more than one such contract, then the consumer selects each of the contracts with a strictly positive probability. As energy is homogeneous, suppliers compete in Bertrand fashion. Therefore, without loss of generality, we consider the duopoly case with two suppliers, using the indices i and i' to represent a supplier's identity.

First, consider the case without a transfer scheme. Take firm i's contract offer p_i. Suppose the consumer's participation constraint (16) holds, then firm i's profit function π_i is given by

$$\pi_i(p_i, p_{i'}) = \begin{cases} (p_i - c)x(p_i), & \text{if } p_i < p_{i'} \\ \alpha_i(p_i - c)x(p_i), & \text{if } p_i = p_{i'} \\ 0, & \text{if } p_i > p_{i'}, \end{cases} \quad \text{for } i \neq i'$$

where $x(p_i)$ is the consumer's energy demand (according to Lemma 1) and $\alpha_i \in (0, 1)$ is the probability that the consumer selects firm i's offer when $p_i = p_{i'}$, with $\alpha_i + \alpha_{i'} = 1$.

Here, consumer utility is strictly decreasing in p (see (26)). Thus, if $p_{i'} = c$, then firm i cannot do better than also setting the price $p_i = c$, in which case profits are zero. Clearly, all other prices cannot constitute an equilibrium, so that $p^* = c$ is the unique equilibrium price.

Now, consider the introduction of a transfer scheme $T(p) > 0$ so that the consumer's participation constraint for a selected contract is given by (14). Facing two contract offers p_i and $p_{i'}$ (both meeting the consumer's participation constraint), the consumer selects the contract with a higher overall utility $CS(p)$. If $p_i = p_{i'}$, so that $CS(p_i) = CS(p_{i'})$, without loss of generality, $\alpha_i \in (0, 1)$ gives the probability that the consumer selects firm i's offer.

Assume $\partial CS(p)/\partial p \geq 0$ at $p = c$ (which holds if $\alpha\overline{x} \geq x(c)$ according to (20)). Firm i's profit function for $p_i, p_{i'} \leq \overline{p}$ is then given by

$$\pi_i(p_i, p_{i'}) = \begin{cases} (p_i - c)x(p_i), & \text{if } p_i > p_{i'} \\ \alpha_i(p_i - c)x(p_i), & \text{if } p_i = p_{i'} \\ 0, & \text{if } p_i < p_{i'}, \end{cases} \quad \text{for } i \neq i'$$

where $x(p_i)$ is the consumer's energy demand (according to Lemma 1) and $\alpha_i \in (0, 1)$ is the probability that the consumer selects firm i's offer when $p_i = p_{i'}$, with $\alpha_i + \alpha_{i'} = 1$. Here, supplier i's contract is selected for sure by the consumer whenever $p_i > p_{i'}$ holds, while it is selected with some positive probability α_i whenever $p_i = p_{i'}$ holds. It is then immediate to see that $\overline{p}$ is the unique equilibrium energy price. Clearly, any pair of prices with $p_i < p_{i'} \leq \overline{p}$, can be ruled out because then firm i has a strict incentive to increase its price to $p_{i'}$. Moreover, any pair of prices with $p_i = p_{i'} < \overline{p}$ can also be ruled out, because then firm i could increase its price by $\varepsilon > 0$ to gain the entire market and thus to increase its profit. This proves part i) of the proposition.

In all other cases, i.e., when $\partial CS(p)/\partial p < 0$ at $p = c$ holds, then $CS(p)$ either has a global maximum at $p = c$ or at $p = \overline{p}$, which follows from the strict convexity of $CS(p)$ (see (19)). If $CS(\overline{p}) \geq CS(c)$, then $p = \overline{p}$ is the unique equilibrium. If, to the contrary, $CS(c) > CS(\overline{p}) \geq R$, then both $p = c$ and $p = \overline{p}$ are both possible equilibria, while the latter one is strictly preferred from the firms' perspective. By the same reasoning as above, any other price pair cannot be an equilibrium outcome. □

Proof of Corollary 2. Suppose the constraint $F \geq 0$. Then, the equilibrium as specified in Proposition 5 is not feasible, because here $F < 0$. We show that under competition, $F > 0$ can be ruled out, so that $F = 0$ must hold in equilibrium. Suppose $F > 0$. Both firms must make zero profits (otherwise, one firm could increase its profit by reducing F slightly to gain the entire market). Then, $F = |(p - c)x(p)|$ with $p < c$ must hold by the zero-profit condition. For $p < c$, the joint surplus including the transfer, $\Pi(p)$, is increasing in p by part ii) of Lemma 3. Thus, increasing p strictly increases the joint surplus, and by reducing the fixed payment in the right way, the additional joint surplus can be divided in a way such the consumer is strictly better off and the firm can win the consumer, and also the firm is strictly better off. Thus, there cannot be an equilibrium with $F > 0$. It then follows that $F = 0$ must hold, so that the equilibrium must be the same as in the linear case, which is given in Proposition 7. ☐

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